SEMIANNUAL PROGRESS REPORT

Research Grant NsG 694

Due June 1, 1965

September 1, 1965

Illinois Institute of Technology

Department of Chemical Engineering

Chicago, Illinois 60616

Herbert Weinstein
Assistant Professor
Principal Investigator

T. Paul Torda
Professor
Co-Principal Investigator

All phases of the program have reached the point of bearing fruit. Below are statements of progress to date followed by photographs of the experimental equipment.

1. Coaxial Jet Mixing Experiment.

All equipment has been installed and is in operating condition. This includes blower, rotameters, tunnel and associated equipment. Current work is now being done on obtaining proper initial velocity profiles and calibration of the hot wire anemometers. The following procedure is being used to calibrate the hot wires. Compressed air is metered through a high precision rotameter into a 15' length of 2" schedule 40 pipe. At the end of the pipe a hot wire with an angle adapter is placed approximately 3" into the pipe at the center line. For a parabolic profile the center line velocity is twice the average. The average velocity is calculated from the rotameter setting and thus the center line velocity can be obtained. It is well known for hot wires that power lost by the wire is directly proportional to the square root of velocity. The accompanying calibration curve for the wires show that the power is a linear function of the square root of velocity. Further calibrations of this type are being made with Freon 12 and Freon 12-air mixtures. Concentrations are taken with a specially constructed hot wire probe. Initial shakedown of the tunnel will include obtaining the proper entrance velocity profile before mixing, and effects of honeycomb on the profiles and turbulence levels.

2. Stability of a Heterogeneous Two-Dimension Mixing Region.

The construction phase of the project has been completed. The wind tunnel and supporting equipment are in running condition. Preliminary runs are now being made with air to determine the effect of screen mesh and honeycomb positioning on the intensity of turbulence. The two-dimensionality of the flow is also being checked out.

Three hot wires have been calibrated in pure air and the calibrations have been shown to be reproducible. A cylinder of Freon 12 has been purchased and calibrations are now being made with air-freon-12 mixtures to check the validity of the hot wire anemometer equations in predicting the effect of variable concentration. After the calibration and checking of the equations for simple hot wires has been completed, the aspirating probe and the x-array hot wires will be calibrated.

3. Computer and Correlation Phase.

The computer program for the non-isothermal, variable density coaxial flow analysis has been used successfully to predict the temperature and velocity profile data obtained in Burley and Bryant, NASA Memo 12-21-58E, 1959; and the concentration profile data obtained in Ragsdale and Weinstein, NASA TND-2121. Slugflow initial profiles were used for concentration and velocity.

Matching of profiles at axial distances beyond the inlet becomes necessary when one cannot safely assume slug flow at the inlet, i.e., a pseudo-initial condition is determined by matching the computer calculated profile and the experimental profile at some axial distance downstream of the inlet. This match process and data fitting is currently being carried out for the following data:

1. Zakkay, Krause, Woo; Pibal Report 813, March, 1964

2. Alpinieri; AIAA Journal, Vol. 2, No. 9, 1964

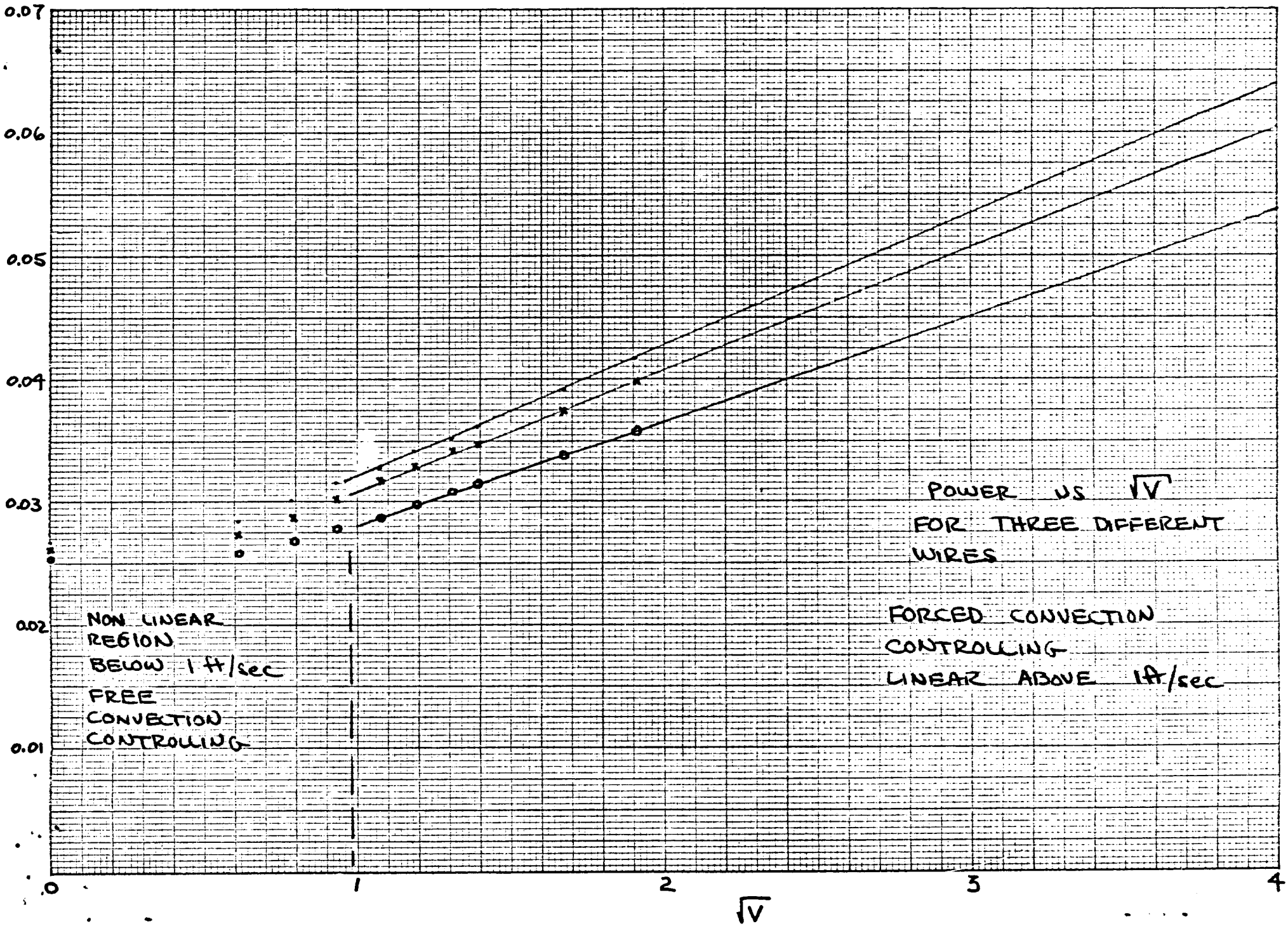
3. Schlinger, Sage; JPL Report 4-108, October 6, 1949

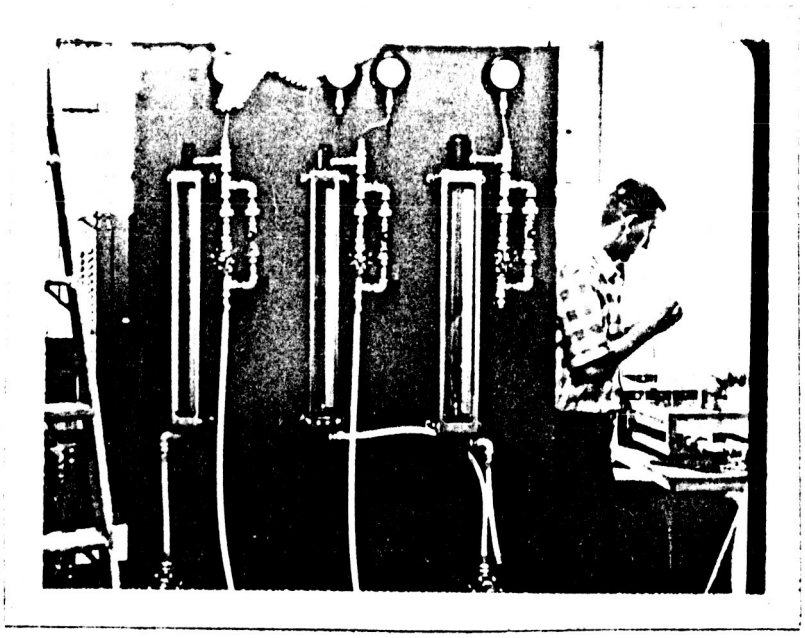
4. Analytical Stability Investigation.

The method developed for the investigation of the stability of the mixing region consists of the solution of the boundary value problem using non-steady non-linear equations and introducing a disturbance of arbitrary amplitude and frequency. The time and spatial history of the distrubance is studied as it affects the mixing region. By varying the amplitude and the frequency, stability criteria are developed.

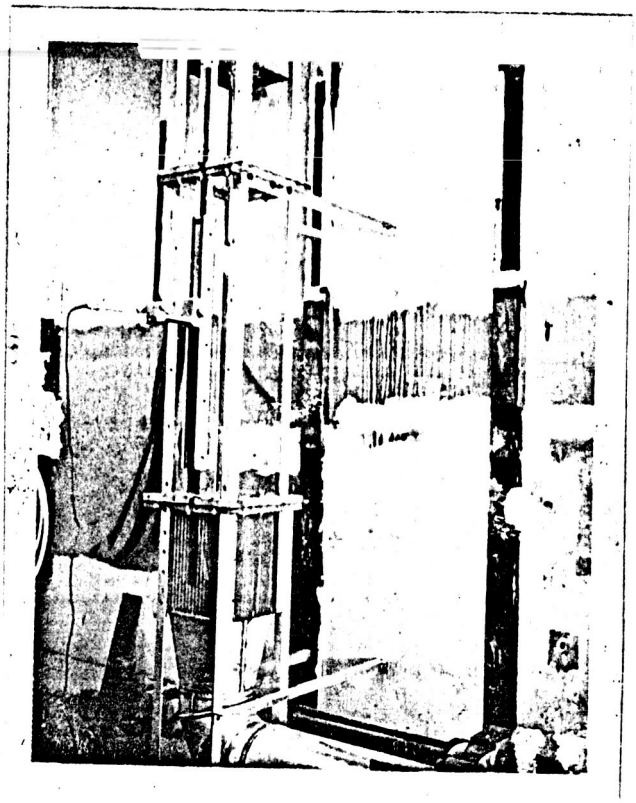
(a) Two-dimensional Case. The non-steady boundary layer equations for the two-dimensional bounded flow in the mixing region were written. Numerical solutions were obtained by finite differences. The solutions are modified to yield solutions of the related initial value problem. Computations on the initial value problem are in progress.

(b) Three-dimensional Case. The Navier-Stokes equations and the continuity equation are being used to investigate the non-steady axi-symmetric flow. The equations are elliptic (and non-linear) so a relaxation method is being used for the numerical solution. Boundary conditions are prescribed over the entire surface bounding the flow region, i.e., on the pipe axis, the cylindrical wall, at the inlet cross-section, and a cross-section far downstream. Stability is tested by introducing a three-dimensional distrubance to the non-steady solution. Programming is in progress.

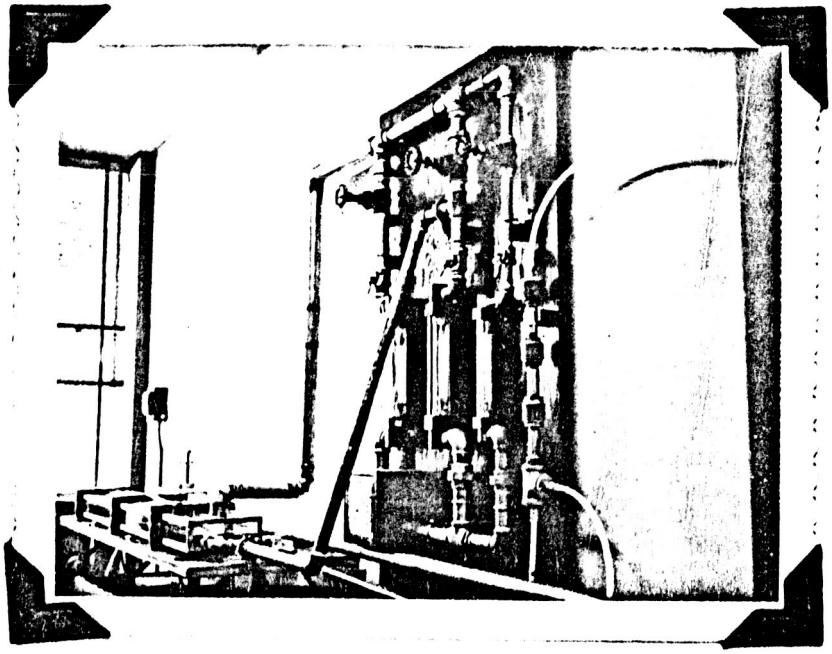




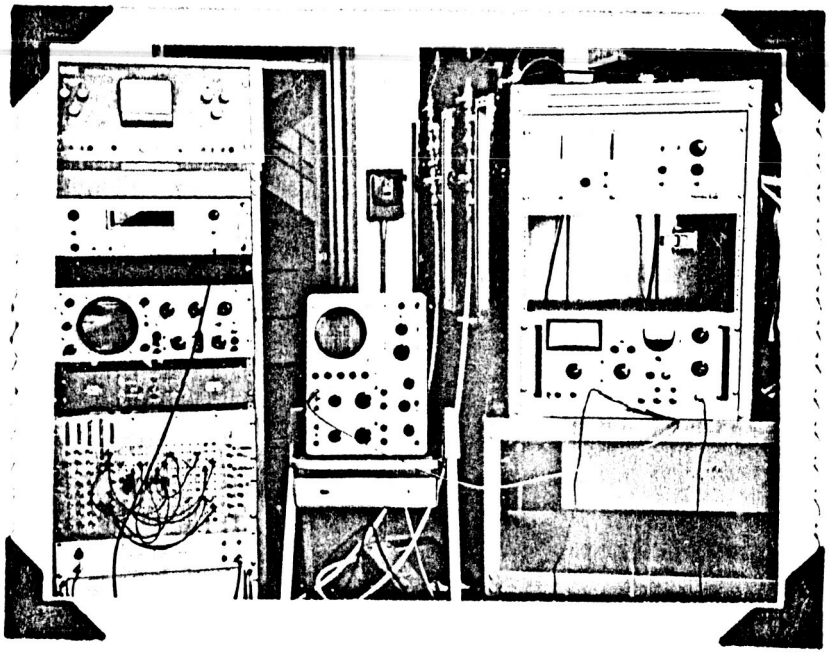
Freon Supply Metering System



Coaxial Mixing Rig



Air Supply and Stability Rig



Instrumentation Electronics